A "SMART" APPROACH TO VV&A

Dr. Paul R. Muessig
Naval Air Warfare Center, Weapons Division (Code 418100D)
China Lake, California 93555-6001

ABSTRACT

The Susceptibility Model Assessment and Range Test (SMART) Project was commissioned in FY92 to develop, test and transition to DoD a proven and efficient credibility assessment process for joint-use aircraft survivability models and simulations (M&S) currently supporting major weapons system acquisition and testing decisions. SMART is sponsored by the Joint Technical Coordinating Group for Aircraft Survivability (JTCG/AS), is funded by OUSD(A&T)/DT&E, and enjoys tri-service participation and support. It is scheduled for completion in FY95.

SMART integrates the key elements of M&S credibility (verification and validation (V&V), and configuration management (C/M)) into a process that provides essential information to decision-makers and analysts to support accreditation decisions for survivability M&S.

This paper describes the development history of the SMART V&V and C/M processes for these M&S, and the integration of this process into an attack on the accreditation problem. Although focused on V&V and C/M process development for mature aircraft survivability M&S, the approach taken and the lessons learned should be of broad interest to all who struggle with the M&S credibility problem.

INTRODUCTION

A meteoric rise in the capabilities of computer M&S to replicate complex phenomena, coupled with a precipitous drop in defense outlays, has made M&S an extremely attractive alternative to costly testing in the weapons system acquisition process. M&S are used in nearly all phases of the acquisition cycle (figure 1), from concept development to operation and maintenance. The high priority placed on the war fighting capabilities of the few systems affordable in an austere defense environment has resulted in an ever more urgent requirement to ascertain the credibility of those survivability M&S that support their purchase.

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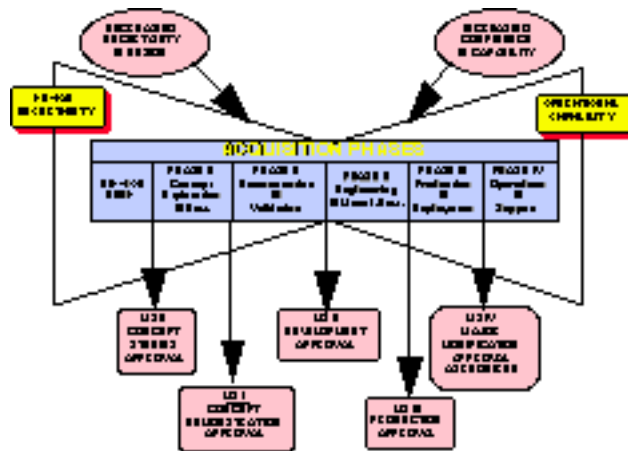| Report Classification unclassified	Classification of this page unclassified
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Figure 1: M&S Use in the Acquisition Cycle

It was into this environment, and to satisfy this need, that the SMART Project was commissioned in FY92. It's goal has been to develop, test and transition to DoD an efficient credibility assessment process for joint-use aircraft survivability M&S. The models selected to develop and test the credibility assessment process are well known survivability analysis models: the Enhanced Surface to Air Missile Simulation (ESAMS); the Advanced Low Altitude Radar Model (ALARM); the Radar Directed Gun System Simulation (RADGUNS); the Trajectory Analysis Program (TRAP); and the Air to Air System Performance Evaluation Model (AASPEM).* These models were chosen by a tri-service executive level "Senior Steering Group" because each of them was (and is) currently used to support major air weapons system acquisition and testing decisions across the services.

ESSENTIALS OF M&S CREDIBILITY

Over the last decade or so, it has become conventional wisdom that the key elements of M&S credibility are verification and validation (V&V), configuration management (C/M), and accreditation. A few years ago, the arcane workings of "VV&A," and the supporting functions of C/M, were understood only by software engineers. Today, the term is on the lips of senior policy makers and program managers across the services and DoD. Much of the credit for this is due to the Military Operations Research Society (MORS). In it's laudable Simulation Validation (SIMVAL) program, the following definitions were proposed for these terms:

> **Verification:** The process of determining that a model implementation accurately represents the developer's conceptual description and specifications.

> **Validation:** The process of determining the degree to which a model is an accurate representation of the real world from the perspective of the intended uses of the model.

> **Configuration Management:** A discipline applying technical and administrative oversight and control to identify and document the functional requirements and capabilities of a model, control changes to those capabilities, and document and report the changes.

Accreditation: An official determination that a model is acceptable for a specific purpose.

Although there is still disagreement as to the practical meaning of these terms, the MORS definitions have provided a convenient focal point for V&V and C/M process development in the SMART Project, which is really the first attempt to put them to practical use on a large scale.

SMART integrates the "arts" of verification, validation and configuration management (figure 2) into a "science" that provides essential information to decision-makers and analysts who must accredit survivability M&S for use in weapons system acquisition and testing. The development history of the individual pieces of this process is instructive for it's insights into what constitutes M&S "credibility" on the practical level, and how credibility relates to "accreditation."

V&V PROCESS DEVELOPMENT

It is impossible to appreciate the contributions that SMART has made to the development of V&V and C/M processes for survivability M&S without understanding the M&S environment in which SMART found itself when it began it's Herculean (and occasionally Sisyphean) task. The following sections, therefore, define the purpose of each piece of the credibility assessment process, describe the unique challenges SMART faced in designing and applying a V&V process to mature M&S, and conclude with a summary of progress in each area. We will then turn our attention to applying V&V and C/M to the pursuit of the Holy Grail: accreditation.
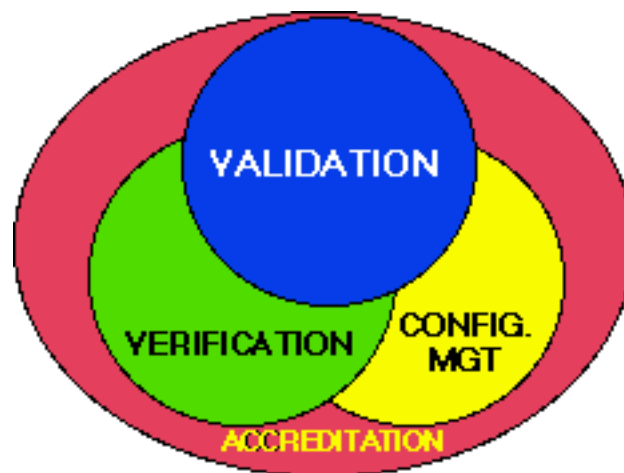

Figure 2: Accreditation and M&S Credibility

Verification

Why Verify? Verification establishes that software design specifications and requirements have been identified, documented, and compared with their implementation in the code. This process flushes out design and coding errors early in the M&S development cycle, making them more cost effective to repair. Verification provides documented confidence in code accuracy, and in M&S design, assumptions, limitations and constraints.

Verification Challenges. Although reasonably straightforward for M&S in development, the attempt to develop a verification process for mature M&S encountered four distinct challenges:

1. The codes for mature M&S were developed before detailed software design, coding and verification standards were in place. The issue of which of the myriad current standards should apply, and how they should be applied, to mature M&S therefore became paramount.

2. Among M&S users, there was a poor understanding of the verification process in general, and no understanding of its technical elements. Developing consensus among users as to the technical constituents of verification, therefore, became difficult.

3. There was poor documentation of prior verification efforts. This made it difficult to avoid reinventing the wheel in some cases. Coupled with an unclear definition of verification as above, it became clear that the documentation of technical results and the development of a corporate memory of M&S credibility assessments should be one of the central tenets of SMART Project philosophy.

4. There was (and is) a profound fear of cost. Many in the M&S community had heard the beat of distant drums from the software development community about verification, and the drums tapped out "bring da money" to a lively rumba beat. This led to a tendency to avoid the verification problem altogether by redefining verification in such a way as to reduce its relevance to the problem of M&S credibility, thereby exacerbating challenge number 2.

The SMART Response. Undaunted at (or ignorant of) the prospect of reprising the Twelve Labors of Hercules, the SMART Project undertook to develop tailored verification plans for three of its five models: ESAMS, ALARM and RADGUNS (figure 3). In doing so, SMART pioneered the process of "verification in reverse," and tailored this process to mature, survivability M&S. We did this by identifying reasonable verification standards in light of DoD, MIL and service standards for software verification, and guidance from each model's developmental and VV&A history. Automated technologies to support the process, such as Computer Aided Software Engineering (CASE) tools, were also investigated and applied where appropriate.
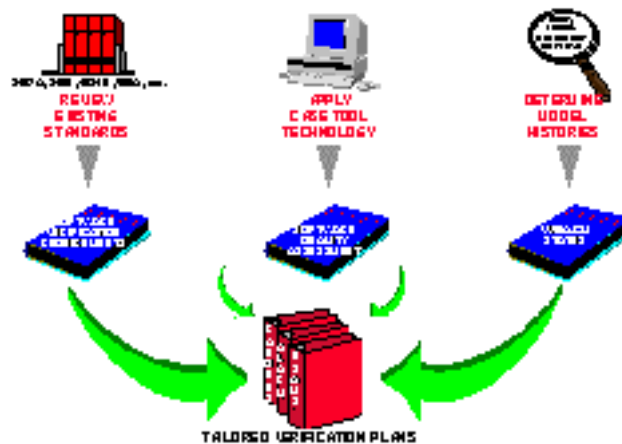
Figure 3: Verification Process Development

The goal of reviewing existing service, DoD and MIL standards (e.g., 2167A, 2168, 1521B, 488A) was to seek guidance on the software verification process, to specify which verification steps were essential to the credibility of mature M&S, and to identify a minimum set of documentation that would establish the credibility of a mature M&S from the verification stand-point. Five pieces of documentation were identified as essential to M&S usage and verification: a Software User's Manual (SUM), Programmer's Manual (SPM), Analyst's Manual (SAM), Design Document (SDD) and Verification Report. Of these, the three models in question had the first three documents in some form or another. The SDD, however, without which detailed verification would be an ignis fatuus, did not exist for any model; likewise the Verification Report. SMART, therefore, pioneered a post-development substitute for the SDD (required by 2167A), appropriately named the Post-Development Design Document (PDDD). The PDDD is the basis for all detailed verification of code.

To capitalize on prior work and experience in verification, we surveyed ESAMS, ALARM and RADGUNS users and developers to establish development, V&V and C/M statuses and histories. Experience confirmed what reason suggested: a dismal (but not wholly unanticipated) state of basic information relating to the history of model development and credibility assessment. This substantiated the need for SMART to do something about the lack of documentation supporting M&S credibility.

Having identified what should be done and what had been done, we proceeded to assess software quality using CASE tools. Factors such as use of standards, adherence to programming conventions, computational efficiency and memory utilization were assessed in order to quantify the relationship between code quality and verification efficiency. With this last piece in place, we developed tailored verification plans for the subject models.

Finally, to address fear of cost, SMART conducted a Pilot Verification Study on the three subject models. Using the tailored plans as a guide, the four highest priority common model functions (based on sensitivity analysis; see below) were verified. The goal was to identify the cost implications of performing "verification in reverse," and to investigate alternative methods of verification. Results of this study are scheduled for publication at the end of FY94.

Progress to Date. In addiition to documentation of the studies described above, PDDDs have been developed for ESAMS, ALARM and RADGUNS which provide detailed software design specifications for these models. Verification Reports are also available, which provide the results of detailed software testing and desk checking for each model at the function level. A verification process paper providing details of process elements and recommendations for application to other M&S is scheduled for publication at the end of FY94. Verification efforts for TRAP and AASPEM are scheduled to begin in FY95, if resources are available.*

Validation Why Validate? The fundamental impetus for validation is a fiscal one; it is cheaper to compute than to test. Validation of M&S permits the replacement of a measurement (test) with a prediction about a measurement (computation). Validation provides confidence that a model behaves like the "real world" (assumed to be well defined), at least within certain specified boundaries (also assumed to be well defined). If we know the domain of conditions over which validation was performed, and the correlation between prediction and observation within that domain, we can determine whether the model behaves enough like the "real world" for a given application by defining criteria for acceptable correlation. But we must have all three pieces of information: validation boundaries, correlation results and acceptance criteria.

Validation Challenges. SMART faced three distinct challenges in developing a validation process for mature M&S:

1. Functional redundancies across M&S were neither identified nor exploited. The resultant "model by model" validation paradigm meant that the same data were being collected multiple times for validating the same functions of different models. If functional redundancies across M&S could be identified and exploited, a few well focused data collection efforts could, in theory, collect enough data to validate large parts of multiple models over a reasonably broad domain.

2. Dedicated, model by model validation testing was (and is) simply too costly. (Fear of cost again). For SMART to fulfill its mission to develop a cost-efficient approach to M&S credibility across service boundaries, it could not squander limited resources on massive, redundant data collection efforts and dedicated testing. The return on investment would be too low. An alternative, high volume source of test data had to be found.

3. Documentation of prior validation efforts was sparse or nonexistent. Although many in the M&S community claimed they had been doing validation "for years," when pressed for documented results, from which SMART could develop an integrated approach, it became apparent that years of work would be irretrievably lost with the retirement of the current generation of analysts. Again, it was clear that the issue of corporate memory was of paramount importance.

The SMART Response. Figure 4 encapsulates, in highly stylized form, the essence of the SMART validation process, developed in response to these challenges.
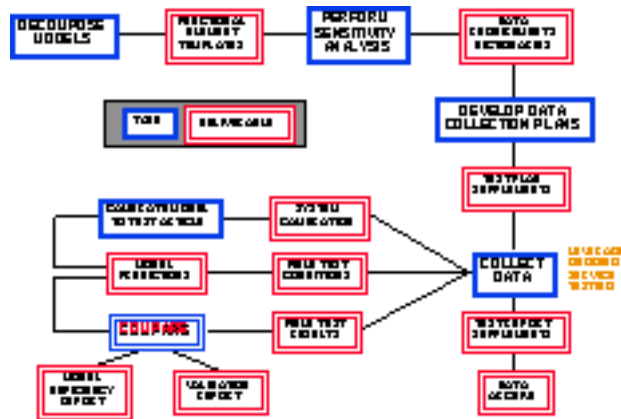
Figure 4: Validation Process

In order to avoid costly, repetitive, dedicated data collection efforts, SMART decomposes M&S into functional elements (FE's), paying careful attention to identifying common functions across them. It then distills the results of the decomposition effort into hierarchical functional element templates, showing both the common and the unique functions of the models. These templates form the basis from which other models can be decomposed and functional similarities identified.

For each FE identified, a two phase sensitivity analysis is conducted for each model. Phase I sensitivity analysis identifies those model functions that have the greatest impact on top level model outputs (e.g., detection range for ALARM, probability of kill for ESAMS, and probability of hit for RADGUNS). The purpose is to prioritize which functions need validation first. Functions with marginal impact on top level outputs become candidates for "face validation" by a panel of subject matter experts (SME's), saving the trouble (and the cost) of explicit data collection for validation of these functions. For FE's with a large impact on top level results, Phase II sensitivity analysis is conducted at the function level, the purpose of which is to identify highly sensitive data elements within each function, and to specify data collection requirements for them (e.g., required accuracies and sampling rates). The resulting list of data requirements for each function across M&S is consolidated into a Data Requirements Dictionary, forming the basis for the development of a library of notional test plans for each FE. These test plans are not specific to any model, but derive their particulars from analysis of all models containing the given function.

Armed with data collection requirements and plans, finding economical sources of data is paramount. SMART attacked this problem by conducting an in depth review of tri-service development test (DT), operational test (OT), foreign materiel exploitation (FME), laboratory and bench test programs, seeking those with promise of providing the data specified in the DRD in accordance with the specifications outlined in the notional test plans. Where possible, Memoranda of Understanding (MOUs) between SMART and relevant test agencies and programs were negotiated. These MOU's provide access not only to test data after the test, but access to the test planning process itself. This allows SMART's data collection requirements to be inserted early enough in the test cycle to impact data collection objectives. Where additional

data can be collected to support model validation objectives, SMART pays for the incremental cost under the auspices of the larger test program. In this way, the high costs of range time, test platform support, system calibration, etc. are avoided, while still collecting a high volume of data.

With data collection objectives specified, and access to test data guaranteed, SMART developed an incremental approach to comparing test data with model predictions. Before detailed comparisons with test data are attempted, system characterization and calibration data from a test article (e.g., a radar or a missile) and system performance as modeled in the code are compared. For example, a missile system's tracking radar may have technical characteristics not modeled in ESAMS (say) because data to support such modeling were unavailable at the time ESAMS was developed. In this case, the test article and the model's simulation of the test article may be profoundly different. Some attempt must be made to reconcile difference between the two, lest comparisons with field test data be meaningless. In some cases, the model is modified to incorporate system features or capabilities. In other cases it is corrected on the basis of system data. In all cases, identification of discrepancies between hardware and model are identified, as well as their possible impact on the conclusions of the validation effort. Comparison of function level test results with model predictions lead to Functional Element Assessment Reports (or, rather prophetically, FEARs).

Comparisons between field test data and model predictions are done by an independent agent. In the case of ESAMS, the independent validator is the RAND Corporation, one of the Air Force's primary ESAMS users, and affiliated with ESAMS sponsor organization, the Air Force Studies and Analysis Agency (AFSAA). The comparison between model predictions and field test observations flushes out modeling and coding errors that result in Model Deficiency Reports (MDR's). These are transmitted to the model developer for consideration under the configuration management cycle.

Comprehensive documentation of the technical details of validation results at both the function level and the model level is contained in the Validation Report, which becomes part of an expanding archive of model assessment information. Test data and their supporting documentation are also archived, providing a body of well documented validation data that may be of use to future users. Both the Validation Report and the Test Data Archive should be available at the end of FY94.

Progress to Date. To date, Functional Element Assessment Reports (or, rather prophetically, FEARs) for nearly all radar functional elements for ESAMS, ALARM and RADGUNS have been produced. Validation of some missile functions in ESAMS and some AAA functions in RADGUNS are also included in these reports. These reports include functional element descriptions, sensitivity analysis results, data collection requirements, and validation results. Data collection efforts for the last two years of the program will focus on expanding the validation space for each of these models, and beginning validation work for TRAP and AASPEM.

Configuration Management

Why Manage a Model's Configuration? Configuration Management is a user support function. A government agent (typically referred to as the "model developer") manages the process of

model change in an orderly, auditable way. C/M functions support users with orderly development, consistency of results across model versions, version control, timely documentation, and error identification, resolution and tracking. The result of all this should be the ability to compare model results across versions, and to prevent (or at least inhibit) version proliferation by keeping the model and its documentation as up to date and useful as possible.

Configuration Management Challenges. No model user can resist the temptation to tinker with a model, however, even a good one. (Are there any "good" models, seen through an analyst's eyes?) Either the model does not perform all the functions the user requires, or else it does not model these functions in sufficient detail for a particular application, or else something. There is always some reason why a model absolutely, positively has to be changed, right now, from its pristine, configuration managed state. As a result, there is a natural tension between model users and model developers.

What keeps this tension in balance is the "leaven" in the C/M bread: money. Model developers must prioritize suggested changes (and occasionally, even error corrections) within the confines of a limited budget, although users occasionally bring money to the C/M table to influence change priorities. If the change priorities that emerge from this resource constrained environment do not meet market (user) needs, the impetus for model changes outside the C/M process increases. The result is fragmented development, inconsistent results across model versions, version proliferation, poor documentation, and unreliable error tracking: in short, the exact opposite of C/M goals.

The SMART Response. Into this user-developer dynamic, SMART has inserted itself with a singular vision: the remediation of C/M woes via the development of consistent C/M requirements and process guidelines across M&S. We believe that consistent standards for C/M are the first step toward consistent implementation and results; conversely, we believe that the lack of standards by which to judge a C/M process or its results leads to inconsistent application of other-wise laudable C/M principles, and enormously complicates an already complicated task. Figure 5 shows the process by which SMART has approached this task.

We began by analyzing current C/M practices across ESAMS, ALARM and RADGUNS, looking for similarities and differences, strengths and weaknesses. So as to heed the proverbial admonition not to rely upon our own understanding, we also conducted user and model developer surveys to identify what these groups thought was good and bad about current C/M practices for their models, and what they wanted to see changed. We analyzed and distilled this information into a set of preliminary C/M process requirements and recommendations, and briefed them to the model developers for consensus and detailed definition. We have now set up a cycle of regular meetings with model managers and users to codify C/M requirements and definitions across ESAMS, ALARM and RADGUNS, with the ultimate goal of incorporating them into a set of consistent C/M process guidelines that can be applied to other M&S.

Progress to Date. Recommendations for improvement based on the work described above have been incorporated into the C/M process for one model (ESAMS). The recommendations attack chronic problems of version proliferation, inconsistent documentation, user communication, and the time it takes to update the ESAMS baseline. The trial run of these revised practices will be in place for one year, and is being monitored for lessons learned that will influence the development of final C/M requirements and process guidelines, with possible extension to model

management for other models in the SMART set.

Work has also begun on documenting the results of our C/M Requirements Study. This document will include a summary of C/M practices for the three subject models, an analysis of the change flow process inherent in each, and a description of the advantages and disadvantages of each approach. The document will also include an analysis of user and model manager surveys, a listing of agreed upon C/M requirements and principles across the three M&S, and a list of recommended C/M process enhancements. The document is intended to be a springboard for the development of integrated C/M policies, procedures and guidelines for survivability M&S that should have broad relevance to other classes of M&S. This document is scheduled for publication in late FY94.

Figure 5: C/M Requirements Study

RELEVANCE TO ACCREDITATION

Why Accredit? Accreditation is the summum bonum, the "Holy Grail," of M&S credibility efforts, focusing the complex technical tasks described above on the very practical question of whether or not a model is "good enough for government work." Without a formal stamp of approval from an accrediting authority, M&S results in support of testing and analysis will always be suspect. One would think it axiomatic, therefore, given our prior discussion of the components of M&S credibility, that accreditation demands satisfaction of a well defined set of acceptance criteria, criteria which would include the requirement for V&V and C/M. This has not typically been the case, however.

Accreditation Challenges. Until very recently, accreditation by acclaim (or fiat) was more or less the rule. If a group of experts or a large body of users had used a model for a long time and felt comfortable with its results, and if the study agent had heard a lot about the model and didn't have many (or any) alternatives, accreditation required no more than a signature. Recognition of a model's name was tantamount to accreditation. This was partly due to the fact that requirements for detailed accreditation policies and procedures have only recently been imposed, and the fact that the accreditation process itself has been poorly understood.

With the promulgation of DoD 5000 series Directives and Instructions relating to M&S over the last two years (especially the most recent DoD Directive 5000.59), more emphasis has been placed on accreditation process development and execution across the services. The Army was the first to respond comprehensively, with its Army Regulation 5-11 (AR 5-11) and its amplifying AR 5-11 Pamphlet, which specified accreditation policies and procedures, and which provided V&V guidelines. The Navy is also developing an OPNAV Instruction relating to the management of Navy M&S, and includes guidelines on accreditation and V&V. The Air Force (particularly AF/XOM and its subsidiary organization, AFSAA) is currently in the throes of M&S policy development that includes V&V and accreditation guidelines much in keeping with the lessons learned during the Army and Navy efforts.

Although similar strains of music are heard in each of these policy directives, the result is hardly euphonious. Two factors drive the apparent cacophony:

1. There are no consistent accreditation requirements or guidelines across the services, making it hard for one service to use another service's models without repeating similar accreditation steps.

2. The application of stated accreditation guidelines, both across and within the services, is equally inconsistent, essentially leaving the meaning of accreditation in the eye of the beholder.

The SMART Response. Figure 6 summarizes the results of SMART's attempt to identify a consistent set of accreditation requirements across the services, and to tailor its V&V and C/M products to meet those requirements.

SMART has developed a set of accreditation information requirements based on emerging policies, procedures and guidelines from across the services and DoD, and has divided its V&V and C/M processes into increments (figures 7A-C) that produce the essential information elements that support accreditation. This incremental process reduces the cost required to accredit M&S by focusing V&V and C/M efforts on identifiable information requirements, and by making the results available to the wider M&S community via an Accreditation Support Database.
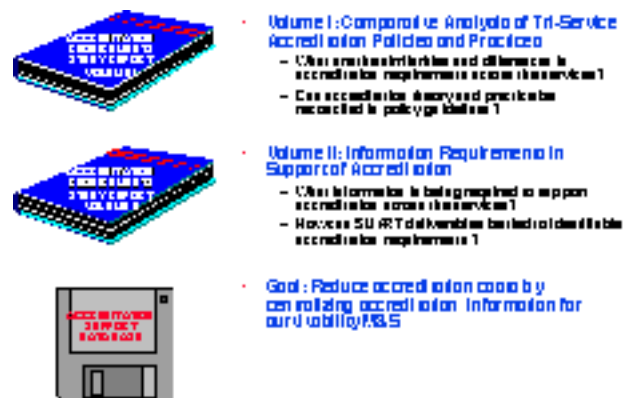

Figure 6: Accreditation Requirements Study Results

SMART's Accreditation Requirements Study led to four conclusions with broad ramifications for accreditation policy and practice:

1. Current and emerging accreditation policies are burdened with excessive administrative overhead, place artificial barriers between the Accreditation Agent and those performing the work, and tend to turn the accreditation process into a bureaucratic, process-oriented, "check the box" operation.

2. Current accreditation practices focus on the collection of essential information elements that relate to various facets of M&S credibility, and place the burden of proof squarely on the shoulders of those responsible for study results. The emphasis of accreditation practice is on information, not process.

3. SMART products satisfy the vast majority of information requirements that support current accreditation practices.

4. The SMART process can be incrementalized to produce these information elements in accordance with the definitions of "levels of accreditation" currently being formulated in policy directives across the services.

Incremental Accreditation

Figures 7A-C depict SMART's incremental approach to the production of accreditation information. Level I Accreditation (figure 7A) provides model users with a baseline M&S characterization. For example, what is the C/M baseline for this model, and how are changes to it controlled? What is the status of model documentation, and how well does it support model use? What is the model's V&V and C/M status and history? What are the inherent assumptions, limitations and errors which must be taken into account before further consideration of the model is warranted? Level I information will likely be collated into a "Green Book Report" which will provide enough information to the prospective model user or accreditation agent to decide whether to continue serious consideration of a model for use in a particular application.

Level II Accreditation tasks (figure 7B) provides more in-depth assessment of a model. Results of detailed sensitivity analyses at both the model and function levels are reported, as well as face verification and face validation of the model by a panel of independent SME's. Coupled with Level I information, the "Yellow Book Report" provides the best possible characterization of the model without actually performing detailed V&V efforts.

Finally, Level III Accreditation tasks (figure 7C) provide the most detailed information relating to model credibility. At this level, a comprehensive verification effort is conducted on model design, logic and code, including software testing, desk checking, and source reporting. Minor errors are identified and corrected; major errors are reported to users and model developers for action via the C/M process. Verification culminates in a comprehensive specification of model design and implementation at the subroutine level. In addition, test data from a variety of sources are compared to model predictions at the function level and the overall level (similar to sensitivity analysis). DT, OT, laboratory, bench, FME and S&TI data sources are all applied to the validation effort to develop as comprehensive a validation space as possible. In the process,

reduced data packages add to the library of information that future users can draw upon to validate similar M&S, and test plans and test reports for each data set provide an audit trail of data use. The results are summarized in a "Red Book Report."

Benefits of Incremental Accreditation

There are numerous benefits to an incremental approach to accreditation. First, accreditation becomes cost effective when future users can rely on information developed by prior model users. Since Level I and II data elements are more or less model specific (vice application specific), they will have broad applicability to other users with different applications for the same model. Moreover, the cost of keeping Level I and II accreditation information current drops significantly once the basic information is gathered and documented.
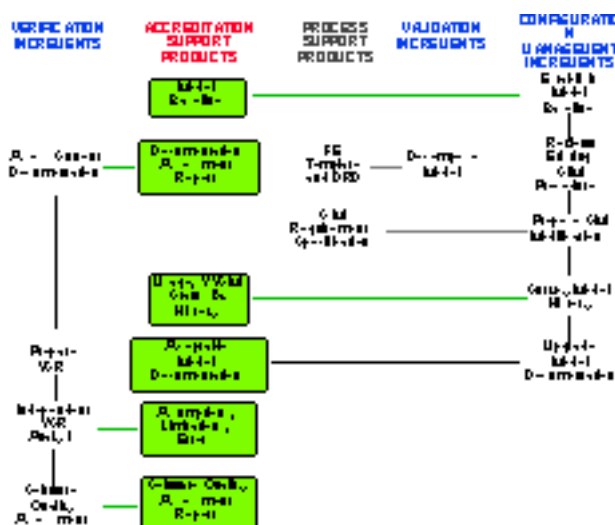

Figure 7A: Level I Accreditation Increments

Second, the various accreditation levels lend themselves to certain "natural" sponsor affinities. For example, the JTCG/AS and the Survivability and Vulnerability Information Analysis Center (SURVIAC) have a vested interest in the development of survivability methodology and the maintenance of survivability M&S; these organizations would, therefore, be a logical sponsor of Level I accreditation efforts. Similarly, model managers (like AF/XOM for ESAMS) are responsible for V&V planning and execution, and for providing their respective user communities with credible models "off the shelf." Building on Level I information elements, these organizations would be a logical sponsor of Level II accreditation efforts. Finally, weapons programs have the greatest need for detailed comparisons of model predictions with test data to support Cost and Operational Effectiveness Analyses (COEAs), Defense Acquisition Board (DAB) reviews, and so on. These organizations would be the most likely candidates to build on Levels I and II, and sponsor Level III accreditation efforts.
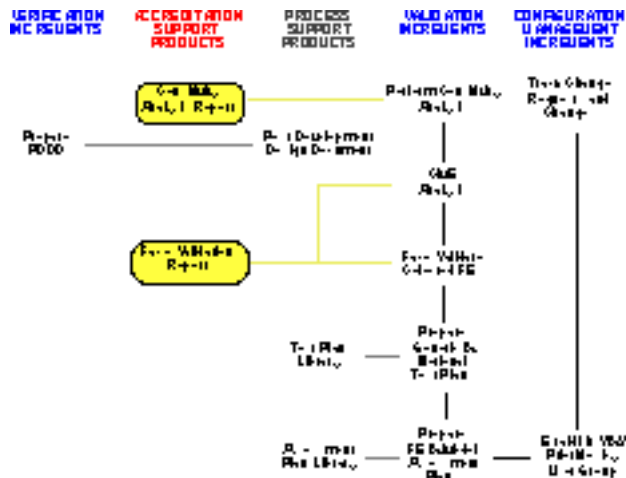
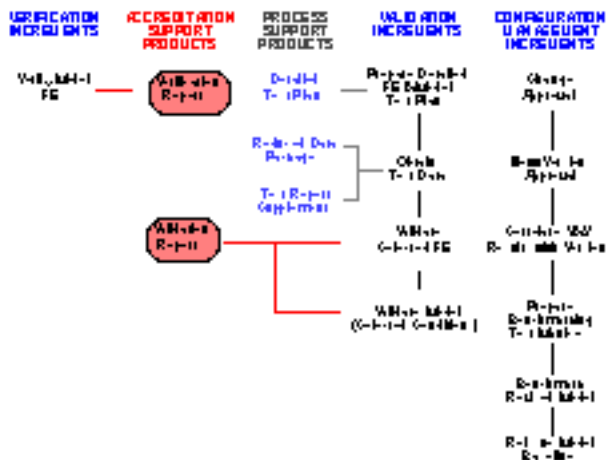**Figure 7B: Level II Accreditation Increments**

Figure 7C: Level III Accreditation Increments

Third, no one sponsor is liable for the cost of the entire V&V for a given M&S. By incrementalizing the accreditation process, and by relating the outputs of each increment to the level of confidence one can place in M&S results, cost effective accreditation at varying levels of detail, to suit varying applications, becomes a reality.

Cost

But all this is abstract theorizing. Cost is a big issue in V&V, and has many service organizations worried about fulfilling the requirements of the accreditation policies being developed. One of the most withering criticisms of V&V in general, and SMART in particular, is that it costs "too much." This mentality can lead to the emasculation of V&V requirements, diluting them to the point of practical insignificance and returning us to the days of accreditation by acclaim.

To address the cost issue, SMART has used the incremental approach to V&V described above

to estimate the cost of each level of accreditation, based on the cost of the technical tasks associated with each increment in the SMART process. Figure 8 shows the approximate cost of each phase of accreditation, based on applying the SMART process to a model equal in complexity to ESAMS.

The ostensibly large costs of Level III accreditation are mitigated by the fact that these efforts would characterize the entire model with at least one data set for each function, and would not be borne by a single user. Priorities for detailed V&V would be driven by the user "market," and the costs over time would essentially be split between users requiring Level III accreditation. Moreover, future users would benefit from prior Level III accreditation efforts, and would only have to fund those V&V efforts relating directly to their application, which would in turn benefit future users.

Figure 8: Approximate Cost of Incremental Accreditation

Accreditation Support Products

SMART Project deliverables include not only documented and tested V&V and C/M processes, but also a series of reports describing the verification, validation and C/M status of each M&S in the SMART set. These reports supply baseline credibility assessments for mature survivability M&S that can support accreditation decisions across the services, resulting in smaller, non-duplicative efforts. As a result of the Accreditation Requirements Study, SMART products are being reformatted to support the accreditation levels defined by the study. This reformulation of SMART products should be complete by the end of FY94.

SUMMARY

SMART has successfully addressed major technical challenges in all areas of M&S credibility assessment. In addressing these challenges, SMART has developed and tested a sound V&V process that supports both user requirements for credible M&S, and service requirements for key information supporting accreditation of these M&S. Fewer and fewer skeptical voices, who early on had "seen this type of thing come and go before," are being heard, and a ground swell of support for the sound technical products achieved by the SMART process is growing.

As a result, SMART is fundamentally altering the way M&S credibility is perceived. The key

elements of M&S credibility, first articulated by MORS, are better understood, and the technical ramifications of these definitions have been explored. Moreover, the relationship between these elements and accreditation is becoming much clearer.

The challenge that both SMART and the M&S community face is twofold:

1. Expanding the scope of survivability M&S that have undergone a SMARTtype credibility assessment process. This will guarantee the utility of the process to the entire class of survivability M&S, and provide an ever-expanding baseline of accreditation support information for them.

2. Applying the lessons learned from the development of the SMART process to other types (non survivability) M&S. From component level simulations of individual electronic circuits to integrated strike warfare training simulators, credibility is paramount to the development of a rational basis on which to save defense dollars using M&S.

The SMART motto is "Credible Models for Credible Analysis." We have done much to make this a statement of fact, instead of just a laudable goal. We need to keep putting our money where our mouth is.

ABOUT THE AUTHOR

The author received his B.S. in Chemistry in 1981 from St. Joseph's University in Philadelphia, and was awarded the doctorate in Physical Chemistry from Brown University in 1987. He began his career as a defense analyst at the Center for Naval Analyses in Alexandria, VA, working on technical feasibility assessments of advanced technology aircraft using M&S. He later became CNA's field representative to the Naval Strike Warfare Center in Fallon NV, contributing to the training syllabus in strike warfare, conducting tactical analyses and coordinating Tactics Development and Evaluation projects.

Dr. Muessig joined the Naval Air Warfare Center, Weapons Division at China Lake, CA in 1989 (then the Naval Weapons Center), working on a project to integrate data collected from strike training exercises to validate survivability assessment methodologies. It was during this time that the idea for SMART began to take shape. A proposal to the Office of the Secretary of Defense (OSD) to develop and test an integrated M&S credibility assessment process utilizing field test data was developed, approved and funded in FY92. Since that time, Dr. Muessig has acted as the Navy Deputy Project Manager and Technical Director for the SMART Project. He is the author of numerous (classified) technical publications, mostly dealing with the validation of survivability M&S using test data.